The impact of using lead pellets on lead contamination of mallards (*Anas platyrhynchos*) in the Czech Republic

Zdeňka Hutařová[1], Olga Čelechovská[2], Vladimír Večerek[1], Zdeňka Svobodová[1]

[1]University of Veterinary and Pharmaceutical Sciences Brno, Faculty of Veterinary Hygiene and Ecology, Department of Veterinary Public Health and Toxicology, [2]Department of Biochemistry, Biophysics and Chemistry, Brno, Czech Republic

Received July 10, 2012
Accepted November 29, 2012

Abstract

The aim of the study was to assess the degree of lead contamination in mallards in the Czech Republic as a result of using lead shots for wildfowling. Two sites used for mallard hunting were chosen, namely a flood-control reservoir in Moravia and a small fishpond in Bohemia. Lead concentrations were determined in the tissues of 20 mallards (*Anas platyrhynchos*) raised at those standing open water sites (n = 10 at each site) and killed there during the autumn hunting season with a steel shot. Control groups were made up of 20 mallards from the same breeding facility as experimental groups but raised in an enclosure without access to water (n = 10 at each site). Lead concentrations were determined in selected tissues (breast muscle, heart, liver, gizzard, kidney, feathers - quill base, lung, brain and humerus) by high resolution continuum source atomic absorption spectrometry. The results showed elevated lead concentrations in all tissues of mallards compared with control in the reservoir in Southern Moravia. The highest lead concentrations (mg/kg) were found in the humerus (14.254 ± 4.525 and 5.083 ± 0.748 for experimental and control mallards, respectively). In contrast, lead concentrations in mallards from small fishpond in Southern Bohemia were lower compared to control. Similarly, the highest lead concentrations were found in the humerus (2.219 ± 0.349 and 8.930 ± 1.012 for experimental and control mallards, respectively). This study extends very limited information about lead contamination of wild ducks in the Czech Republic in connection with hunting activities.

Lead exposure, lead pellets, lead poisoning, hunting, waterfowl

Gamekeeping and waterfowling have for many years been associated with the use of lead shot. As early as in the 19th century, however, first cases of mass waterfowl deaths were recorded in intensively hunted areas and particularly in wetland areas (Mateo et al. 1997). Later research revealed the link between the presence of lead shot at the water sites and cases of lead poisoning in various waterfowl species (Beyer et al. 1998; Guitar et al. 2010). It was found that waterfowl may mistake lead pellets for grit, which they purposefully ingest to facilitate food digestion. Lead pellets present in the gizzard together with grit are ground down, which reduces the size and increases the surface area of lead fragments. This process facilitates the digestion of lead fragments in gizzard and, at the same time, increases the probability that lead (in the form of salt) will enter bloodstream and penetrate further into the bird's organism (Ferreyra et al. 2009). Depending on the number of pellets ingested, diet composition, size, feeding habits and overall health status, the exposed birds may demonstrate symptoms of lead poisoning in varying degrees of severity. The most frequently reported lead poisoning symptoms include lethargy, overall listlessness, green watery diarrhoea, loss of body condition, reproductive problems, and, in the case of acute poisoning; the birds affected may die (Mateo et al. 1997; Francisco et al. 2003; Gad 2005).

Based on these findings, a number of countries have adopted measures to reduce the amounts of spent lead shot in and around water bodies. The measures take the form of a

Address for correspondence:
MVDr. Zdeňka Hutařová
Department of Veterinary Public Health and Toxicology
Faculty of Veterinary Hygiene and Ecology
University of Veterinary and Pharmaceutical Sciences Brno
Palackého tř. 1/3, 612 42, Brno, Czech Republic

Phone: +420 541 562 789
Fax: +420 541 562 790
E-mail: hutarovaz@vfu.cz
http://actavet.vfu.cz/

ban on the use of lead ammunition in high-risk areas. In the Czech Republic the ban on the use of cartridges charged with lead shot came into force on 1 January 2011.

The aim of our study was to discover the degree of lead contamination of mallards living in selected water bodies in the Czech Republic, i.e. to map contamination levels following many years of lead shot use for wildfowling.

Materials and Methods

In our study, we used the mallard (*Anas platyrhynchos*), a cosmopolitan and common representative of waterfowl that is very extensively hunted in the Czech Republic. The degree of lead contamination in mallards was investigated at two selected water bodies where hunting tradition dates back many years. One of the sites was a flood-control and irrigation reservoir, circular in shape and 8.3 ha in size located in Southern Moravia (Experiment 1). The other selected site was a fishpond in Southern Bohemia, of oval shape and 5.9 ha in size (Experiment 2).

Mallards from two experiments were stocked onto the water bodies in March at the age of 3 weeks after hatching. From each of the two water bodies, 10 mallards (5 males, 5 females) weighing 1.05 ± 0.15 kg (experiment 1) and 1.12 ± 0.13 kg (experiment 2), were shot with steel pellets during communal hunts in September 2011. Control groups were made up of mallards coming from the same breeding facility as mallards in experimental groups, but they were raised in enclosures without access to water bodies and were killed by pithing. Mallards from the control groups weighed 1.34 ± 0.07 kg (experiment 1) and 1.33 ± 0.10 kg (experiment 2). Samples of selected tissues (muscle, heart, liver, gizzard, kidney, feathers - quill base, lung, brain and humerus) were collected from birds in both the experimental and the control groups.

Lead concentrations were determined in bird tissues but also in feedstuff fed to mallards raised without access to water bodies and used as extra feed for mallards risen on water bodies. Prior to the determination of lead concentrations, samples were decomposed by the following method. One gram of each of all tissues was mineralised with 6 ml nitric acid and 1 ml hydrogen peroxide in a microwave-heated laboratory autoclave (ETHOS SEL, Milestone, Italy). The sample solution was made up to volume 10 ml by water. Lead concentration was determined by high-resolution continuum source atomic absorption spectrometry (HR-CS AAS) using ContrAA 700 spectrometer (Analytik Jena AG, Germany). Soft tissues and bones were determined by electrothermal atomization and by flame technique (λ = 283.3060 nm), respectively. The detection limit for lead (3σ) was 0.021 $mg \cdot kg^{-1}$, the reproducibility was expressed from five measurements as RSD 3.7 %. Standard reference materials, DORM-2 (NRC, dogfish muscle), 1577b (NBS, bovine liver) and H-5 (IAEA, animal bone), were used to verify the validity of the method.

Statistical analyses were done using Statistica 8.0 for Windows software. After testing for normality, data were subjected to one-way ANOVA and subsequently to Tukey-HSD test or nonparametric ANOVA and Kruskal-Wallis test. A significance of 0.05 was used as the level of statistical significance.

Results

The comparison of lead concentrations (average ± SEM) between tissue samples collected from mallards in experiment 1 is given in Fig. 1. Mean lead concentrations (mg/kg) in all tissue samples examined were higher in the experimental group (heart 0.014 ± 0.002, breast muscle 0.057 ± 0.022, brain 0.162 ± 0.068, liver 0.568 ± 0.263, lung 0.651 ± 0.379, feather 0.911 ± 0.503, gizzard 1.110 ± 0.016, kidneys 1.530 ± 0.79 and humerus 14.254 ± 4.525) than in the control group (heart 0.012 ± 0.001, breast muscle 0.024 ± 0.004, brain 0.042 ± 0.009, gizzard 0.042 ± 0.027, lung 0.118 ± 0.020, feather 0.236 ± 0.055, liver 0.362 ± 0.071, kidneys 1.141 ± 0.168 and humerus 5.083 ± 0.748). In spite of considerable differences in lead concentrations in different body tissues, a significant difference was found only among gizzard tissue samples ($P < 0.05$). Tissues with the highest variability of lead concentrations are listed in Table 1.

Table 1. Variability of lead concentrations (min– ax) in body tissues of experimental group mallards bred out in Southern Moravia (Experiment 1)

Body tissue	Lead concentration (mg/kg)
Lung	0.05–3.62
Feathers - quill base	0.01–4.23
Humerus	1.58–33.24
Brain	0.01–0.56

Comparison of lead concentrations between the experimental and control groups of mallards in experiment 2 is given in Fig. 2. Lead concentrations

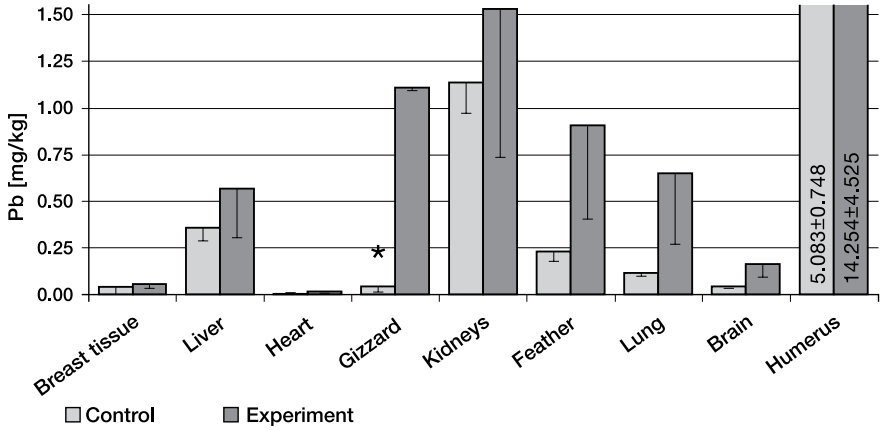

Fig. 1. Comparison of lead concentrations in the tissues of mallards reared in Southern Moravia (Experiment 1)

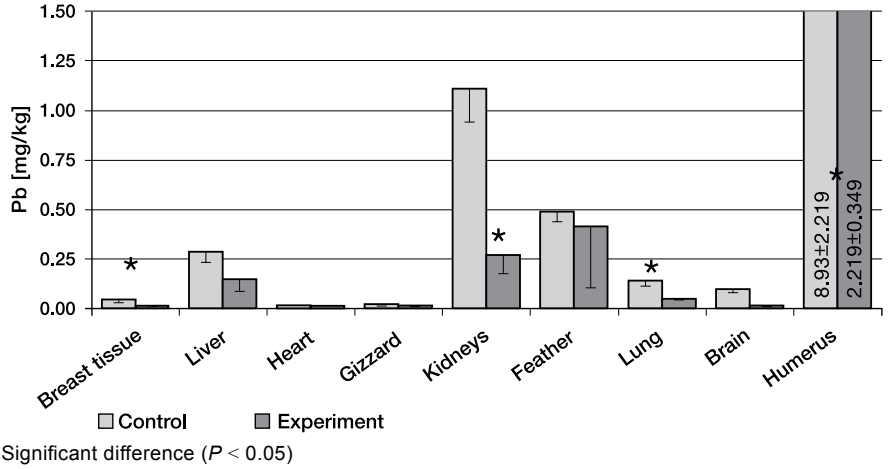

Fig. 2. Comparison of lead concentrations in tissues of mallards reared out in Southern Bohemia (Experiment 2)

(mg/kg) in all tissues examined were lower in the experimental group (heart 0.011 ± 0.000, gizzard 0.014 ± 0.003, brain 0.016 ± 0.006, breast muscle 0.017 ± 0.004, lung 0.051 ± 0.007, liver 0.148 ± 0.059, kidneys 0.271 ± 0.094, feather 0.416 ± 0.310 and humerus 2.219 ± 0.349) than in the control group (heart 0.012 ± 0.002, gizzard 0.024 ± 0.007, breast muscle 0.050 ± 0.021, brain 0.098 ± 0.017, lung 0.140 ± 0.027, liver 0.286 ± 0.052, feather 0.488 ± 0.049, kidneys 1.110 ± 0.170 and humerus 8.930 ± 1.012). Significant differences were found in samples of muscles, kidneys, lungs and bones ($P < 0.05$).

The lead concentration assessed in foodstuff used for the feeding of mallards raised without access to water bodies was 0.042 mg/kg and for extra feeding of mallards rose on water bodies it was below the detection limit.

Discussion

The finding of higher lead concentrations in the tissue of mallards from experiment 1 confirms the hypothesis that surroundings of water bodies utilized for waterfowling suffer from higher degree of lead contamination. Mallards raised on the fishpond may come across a lead shot, which they ingest together with their food. Lead released in the digestive tract of birds is then distributed to individual body organs, which will be manifested by higher lead concentrations in tissues (Mateo et al. 1997). Lead concentrations found in the tissues of the control group (i.e. those raised with no access to water bodies) are probably due to the presence of lead in feedstuff fed to them.

Significantly higher mean lead concentrations in gizzard tissue samples of birds from the experimental group can be explained by the ingestion of lead pellets and their erosion in this section of the digestive tract. In the rest of tissues, no significant differences were identified, mainly because of the high variability of lead concentrations in individual tissues of experimental birds. The wide range of lead concentrations found in individual mallards from the experimental group could be explained by different numbers of lead pellets ingested by individual birds.

In the experiment 2 low concentrations of lead were found in the tissue of experimental mallards. This could be explained by the oval shape and a relatively small width of the fishpond (about 200 m). The position of shooters during mallard hunting is usually along the longer axis of this pond. A waterfowling shot can travel up to 300 m and will therefore fly over the fishpond and fall on fields in some distance from the water body. Risks associated with the presence of lead shots in close vicinity of fishponds (where lead pellets may be mistaken for grit or ingested together with food by birds foraging along pond banks) are thus considerably reduced. Foods sought after by mallards in fields consist mainly of ripe corn and germinating crops and do not represent a dominant food source for mallards.

The diet fed to the control group of mallards in both experiments 1 and 2 contained lead at a concentration of 0.042 mg/kg. The weight of mallards in these two groups was comparable. Lead concentrations found in tissues of two control groups were also comparable. The highest mean lead concentrations were found in bone tissues and in kidneys. The lowest lead concentrations, on the other hand, were found in the heart, gizzard and muscle tissue. Tissues of experimental mallards exhibited similar trends with regard to the lead distribution in individual tissues. The highest mean lead concentrations were in bone and kidney tissues. The lowest mean lead concentrations in experiment 1 were detected in heart and breast muscle tissue, and in experiment 2 the lowest lead concentrations were found in the tissue of heart, gizzard, brain and muscle tissue. High dispersion of lead concentration in mallard tissues shows evidence for different shot ingestion rates in individual birds.

The highest lead concentrations in mallard bone tissue were also reported in the study of Kalisińska et al. (2003). Contrary to our results, however, they reported muscle as the tissue with the second highest lead concentrations. The lowest lead concentration was found in the liver. Bojar et al. (2008) mentioned liver as a tissue with the highest lead concentration. Mapping the lead distribution in individual organs and tissues is difficult in view of the inconsistency of the published results. The tissues considered to have the highest lead concentrations shortly after ingestion of lead particles are the liver and kidneys (Fisher et al. 2006). Lead concentrations found in the examined tissues may therefore vary in dependence on the time that has lapsed since the ingestion of lead particles. High lead concentrations in bone tissues correspond to the generally described trend of lead

being accumulated in bone where it may remain for up to several years and is therefore used to express exposure to lead over time (Fisher et al. 2006).

The results of our study support the hypothesis of higher contamination degree at open water sites where lead shots were used for waterfowl shooting. The presence of lead shots left around ponds by hunters affects the degree of lead concentration in the tissues of mallards. The degree of lead contamination of mallard tissues depends on many above mentioned factors. Two important predisposition factors influencing the degree of tissue contamination seem to be the size and shape of the water bodies. The degree of lead contamination of mallard tissues raised at a small oval-shaped fishpond whose width is less than the distance travelled by shot pellets is low.

Acknowledgements

This study was supported by University of Veterinary and Pharmaceutical Sciences Brno (grant IGA VFU 76/2011/FVHE).

References

Beyer WN, Franson JC, Locke LN, Stround RK, Sileo L 1998: Retrospective study of the diagnostic criteria in a lead-poisoning survey of waterfowl. Arch Environ Contam Toxicol **35**: 506-512

Bojar H, Bojar I 2008: Assessment of the lead and cadmium contamination levels in the Lublin region wetlands using mallards (*Anas platyrhynchos*) as a contamination vector. Environ Toxicol II **110**: 139-147

Ferreyra H, Romano M, Uhart M 2009: Recent and chronic exposure of wild ducks to lead in human-modified wetlands in Santa Fe Province, Argentina. J Wildlife Dis **45**: 823-827

Fisher IJ, Pain DJ, Thomas VG 2006: A review of lead poisoning from ammunition sources in terrestrial birds. Biol Cons **131**: 421-432

Francisco ND, Troya JDR, Agűera EI 2003: Lead and lead toxicity in domestic and free living birds. Avian Pathol **32**: 3-13

Gad SC 2005: Lead. In Wexler P (Ed.): Encyclopedia of Toxicology. Academic Press, Oxford, UK, pp. 705-709

Guitar R, Sachana M, Caloni F, Croubels S, Vandenbroucke V 2010: Animal poisoning in Europe. Part 3: wildlife. Veterinary J **183**: 260-265

Kalisińska E, Salicki W, Mysłek P, Kavetska KM, Jackowski A 2004: Using the mallard to biomonitor heavy metal contamination of wetlands in north-western Poland. Sci Total Environ **320**: 145-161

Mateo R, Martínez-Vilalta A, Guitar R 1997: Lead shot pellets in the Ebro delta, Spain: Densities in sediments and prevalence of exposure in waterfowl. Environ Pollut **96**: 335-341